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VOL. LXIV, No. 1651

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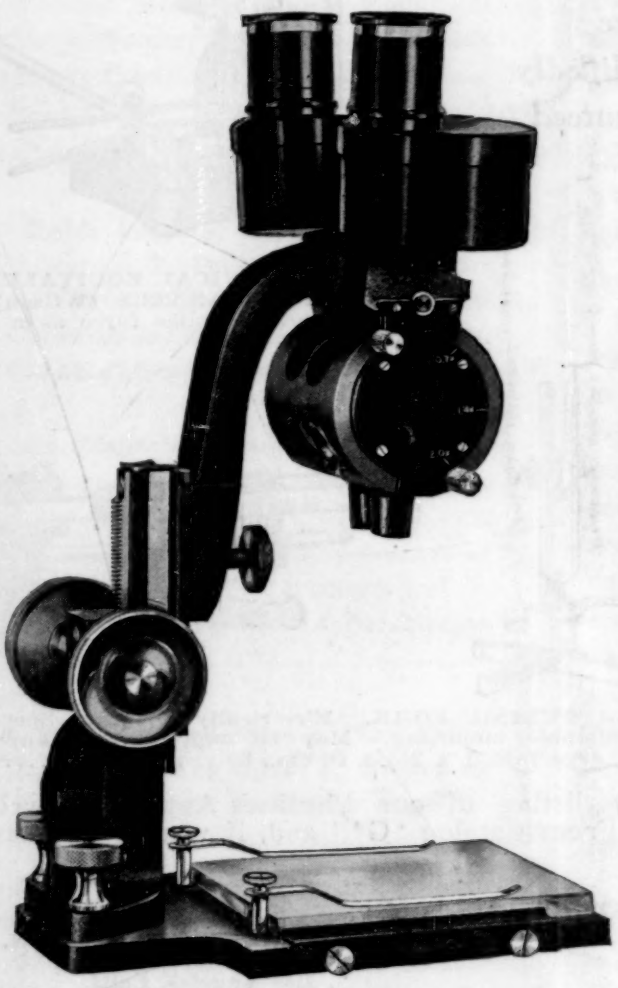

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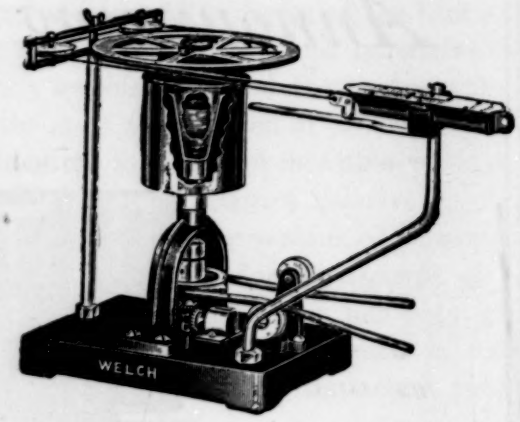

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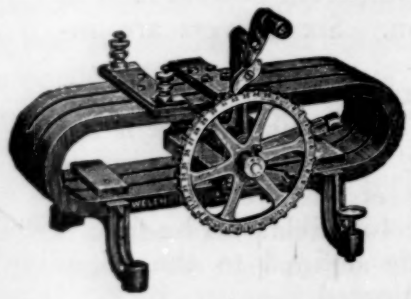

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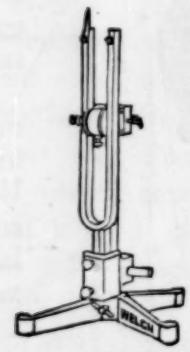

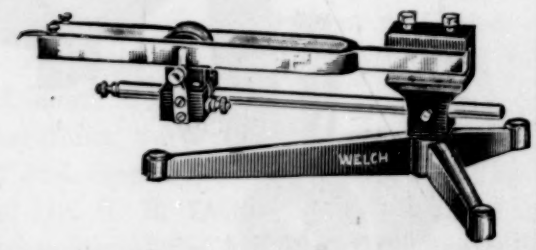

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SCIENCE AND CIVILIZATION[1]

IF we go no farther than the dictionary, "science" implies organized knowledge, while "civilization" implies those arts and practices which pertain to a community life. But a community life, whether from the viewpoint of the clan, the village, the city, the state, the nation or the community of nations, implies specialization and cooperation. It means that one individual or group of individuals shall devote, in a restrictive way, time and human effort to the performance of some one task in an expert or specially effective way. And thus, with many individuals or groups of individuals, many tasks are undertaken, many things are accomplished and all go as contributions into the great pool of human product, and from which each individual or group of individuals, in return for its own contribution, draws the varied elements of life and comfort.

As we approach a more and more fully objective view of our world as it now is—a view and judgment as by our distant cousins on Mars—we shall perhaps see more and more clearly that the entire fabric of our present civilization is based on this reciprocal relation of give and take, like some vast chemical reaction which is ever proceeding toward some ultimate condition of equilibrium, but to which it will perhaps never attain. There is, then, this great pool of the product of human effort. Each individual, by contributing in some relatively expert fashion the product of his own effort, time and energy to this pool, becomes entitled thereby to draw therefrom such portion of the products of his fellows as he may need or as his own contribution may merit.

And furthermore, a wide range of the most serious problems of our civilization center about the ways and means of effecting this exchange and interchange. How as individuals may the farmer, the miner, the mechanic, the tradesman, the banker, the professional man, place most efficiently each his own contribution in this great pool and draw therefrom those contributions of others, needful and reasonably sufficient for life and comfort?

It was not always thus. There was a time in the evolution of man, when the individual, or at most the

[1] Address given at the Mills College meeting of the Pacific Division of the American Association for the Advancement of Science, June 18, 1896.

family, was the unit and was of necessity sufficient unto itself. There came a time, however, when man set his foot on the gradient leading toward our modern condition; and that was perhaps in the days of our paleolithic ancestors, when some one man began to develop an especial skill in the forming of flint arrow or spear heads, or when some one acquired special aptitude in the weaving of crude basketry or in the making of the rough early forms of pottery and earthenware. Just so soon as special skill or aptitude becomes set apart for the doing of some one of the things needful for life, just at that point do we find the foundation of barter and exchange and of the cooperative scheme of life which we have developed to such vast complexity in our own days.

But progress in civilization, conditioned upon the exercise of special skill or aptitude, implies a field for the exercise of such specialized human effort. This is, of course, the whole domain of nature in her various manifestations in the form of matter and of energy—if we care to still retain the distinction between these two concepts of our objective world.

The products of the earth and the energies of nature have thus furnished the field wherein has been exercised the specialized efforts of man, and the products of which have constituted this ever-swelling reservoir from which the elements of civilization have been drawn.

But all this must obviously require an acquaintanceship with nature and with her so-called laws—more, it must require a working partnership with her and clearly, as our acquaintanceship is the more extended and our partnership the more sympathetic, so will our work with her be the more effective—so will our great reservoir the more widely extend its borders and so may our individual draughts from it be deeper, fuller and richer.

And again, in order that the progress made by one individual or by one generation may not be lost to those which follow, there must be an organized record of this entire body of our understandings with nature; only by such record can progress be made continuous; only thus can such understanding be made to constitute a gradually accumulating and expanding integration of its divergent and discrete elements.

But what is science but an acquaintanceship with nature, and what is our organized record of science but the expression of the terms of our partnership with her?

If, then, we ask of the relation between science and civilization, the question answers itself. If civilization is a result of our gradually improving utilization of nature's products and energies through a more and more effective partnership with her, and if science is the organized body of our understandings and agreements with nature, the two are seen as inseparable parts of one whole. There could be no civilization without science—and, given a body of science with rational beings, a civilization must result.

At this point, perhaps, a word may be in order as to the two phases of science known under the broad terms of fundamental and applied. In so far as the distinction is valid, the emphasis in the former is placed on the extension of the boundaries of our acquaintance with nature—on adding to the sum of our organized knowledge; while in the latter, the emphasis rests on the application of such knowledge to some specific end in the service of humanity. Actually, the two are inextricably interwoven. The prosecution of problems in fundamental science can not, in general, be carried on without the means—apparatus, equipment, etc.—provided through activities in applied science. It is not, perhaps, going too far to say that, in general, the whole domain of research in fundamental science, and with special reference to experimental research, calls upon the entire organized domain of applied science for its material ways and means. On the other hand, applied science is continually asking aid of fundamental science in the solution of special problems which arise in connection with the realization of specific ends. The two are bound together as inseparable parts of one whole. Neither alone can meet the full requirements for human progress. Both are fundamentally essential. However, in so far as there is a distinction to be drawn between these phases of scientific work, the American Association for the Advancement of Science is an aggregation of those in whose work the primary emphasis is more commonly placed on fundamental rather than on applied science and our thoughts this evening will the more properly focus themselves on the relations of so-called fundamental science to civilization.

I shall not take the time to attempt to recite any catalogue of scientific achievements which have borne fruit as expressed in essential elements of our modern civilization, nor, on the other hand, any list of such elements which trace back to sources in fundamental science. To do so in any even reasonable degree would be to catalogue, on the one hand, hundreds or even thousands of achievements in the various domains of fundamental science and on the other, to list substantially the entire material content of our modern civilization.

It will be in order, however, to deal in broad terms with the special place which fundamental science occupies in our scheme of civilization. Thus, as we have seen, the worker in this field is concerned primarily with enlarging the boundaries of our knowledge, noting new observations of fact, discovering new laws,

new relations, with linking up terminal facts or elements of science with certain basic elements or concepts, such as space, time, matter, energy, electrons, protons, quanta, an ether, etc.—and all independent of special thought as to how these particular items are to be built into the fabric of our civilization. But is it not evident that this product of labor in fields of fundamental science furnishes the material for the fabrication of the fundamental building blocks out of which the structure of our civilization must be reared. With a body of science comprising a few isolated facts of nature we can postulate a civilization of the order of the paleolithic or even the neolithic stages of culture. With some further extension of the boundaries of our acquaintance with nature, we may postulate a civilization represented by the kitchen middens or the lake dwellers; with something further, we have a foundation for the civilizations of the pre-Homeric and earliest Egyptian ages; and so on, as the body of fundamental science enlarges so may we find foundation on which to erect the ever-expanding material content of human civilization.

It is, of course, only necessary to note in passing that in these earlier stages of the evolution of our civilization there was nothing which could be called science in the sense of an organized body of knowledge regarding nature. Nevertheless, there was a more or less indefinite body of empirical knowledge. The paleolithic stone chipper knew the properties of his flint and how, cunningly, to apply pressure or impact in such way as to produce the forms desired—an empirical knowledge combined with a manual skill which produced, at its culmination, products which for beauty of form and finish have never been since excelled, if indeed equalled. In like manner the prehistoric potter knew the action of fire upon clay and the adaptabilities of various clays to his needs, and the basket weaver knew his osiers, reeds and grasses. Perhaps the most important single step made by man in his slow progress through the dawn stages of civilization was that which gave him an empirical knowledge of fire, its production, control and preservation, and its effect on various substances—in particular on those which he had learned to find available as food.

No form of what we call civilization is even thinkable without fire under control in the service of man and that ancient empirical scientist, brought down to our day through the Grecian legend of Prometheus, stands as the great prototype of those who in later years have so extended and deepened our observational acquaintance with nature.

But these early approaches toward an understanding with nature were halting, disconnected and imperfect in method, and the results realized were correspondingly inadequate as building blocks for an advancing civilization. For thousands upon thousands of years after these dawn stages there was little change—down through the centuries of the old stone age, the new stone age, the bronze age, and on to within the reach of recorded history, there was but slight change in the mode of approach toward this problem of improving our understandings with nature. Always there was a gradually growing total of empiric knowledge, but without organization or interpretation. Mention by name need only be made of the scientific systems, if we may so call them, of ancient civilizations—Babylonian, Persian, Egyptian, Phoenician, Grecian, Roman.

Only in recent times have we been able to develop and organize, in what we believe to be its most effective form, the grand strategy which determines our plan of operation in pushing ever more deeply into nature's mode of work and in associating ourselves more and more effectively with her. All of this has come about, largely since the days of Francis Bacon, and in consequence of the formula—observe, record, analyze, compare, relate, generalize, test, reject, and select.

However, to return to our main thesis, it is obvious that the body of organized knowledge which has, in this manner, been growing ever more rapidly in recent times, must form the building stones out of which, through adaptation to special ends, we may erect our structure of civilization. With scanty building material, so will our structure be mean and inadequate. With an arrest of the provision of new material, so correspondingly will our structure be limited; for while we may, perhaps, combine the elements which represent our present body of fundamental science into many new and as yet unknown applications to the needs of human life and progress, yet there must be a limit to the number of such combinations. If fundamental science should cease to grow from to-day forward, we might thus go on for a time with new combinations of old material. But the end of progress would soon come. We should find ourselves simply beating old straw or, to vary the figure, moving in closed orbits and without progress toward any vast unfolding purpose.

This leads to the first important point which I would make and that bears upon the responsibility which rests upon the great body of workers in fundamental science, with regard to the part which they are called upon to take in our progress as a race along an ascending gradient of civilization. The part is obviously that of pioneers. They are the vanguard; they must blaze the way, working always on the outposts and along the boundary line between the known and the unknown. They stand thus as the first line of contact between civilization on the one

hand and the vast areas of nature's unknown on the other. If they falter, so will the progress of civilization lag. As they push forward, so will civilization follow. Can there be conceived a position of larger opportunity or of graver responsibility?

But if the responsibility for the carrying on of faithful and effective work in fields of fundamental science rests thus weightily upon those who have chosen this as their field of work, the responsibility is not theirs alone. The prosecution of work in science requires two major factors, human time and effort, and material means. It can hardly be expected that those who have chosen this as their field of human effort can supply more than the first of these two components. Successful work in fields of science must depend upon an effective co-partnership between those who are able and willing to supply the human element and external sources of material support.

These external sources, it is clear that we must characterize as society at large; and primarily because society at large is the beneficiary of the work of the scientist. The past quarter century has witnessed a marvelous expansion in the material content of life and all tracing back ultimately to work in fields of fundamental and applied science.

In our daily routine of life we have come to look upon, as commonplace, facilities and privileges which a few years ago would have seemed beyond the reach of the imagination. Society is now demanding these as the routine elements of our daily round of life, and like Oliver Twist, is always calling for more. Whether all this is good for us as members of society, individually or collectively, is open to question. It does not follow that because we have more of facilities and privileges, based on the utilization of the materials and energies of nature, we are thereby any better, wiser or happier. These are qualities which spring from within rather than from without.

Indeed, the whole question of the responsibility for the use to which the products of the work of the scientist are put is one of the deepest interest, not only to the scientist himself but to society at large. The same scientific result, accordingly as it may be applied, may secure better and larger food crops or serve as an explosive agent carrying death and destruction in its wake. The same drug may be used to kill or to cure. The same vapor may be employed as an aid to the surgeon or to the midnight robber and murderer. The same implement may serve for protection or for aggression; the same chemical substance as a medicine or as a degrading drug; the same means of pleasure or recreation may be used for recuperation or for dissipation and waste. And so throughout the whole domain of our modern civilization, contributions made by the scientist may commonly enough be used, either wisely or foolishly. They may be used to build up or to destroy. Whose the responsibility?

Surely the scientist in the exercise of his function as such should not be held responsible for the use to which his discoveries are put by society at large. This must rest rather upon society, at least in so far as we can conceive of responsibility as attaching to so vast and inchoate a body. Society is, however, made up of individuals and responsibility may rest upon an individual. And so, as an individual member of society, the scientist must accept his own share of this responsibility.

There are some, in modern days, who go so far as to fear that the modern developments of science—the material content of this modern scientific age—may after all prove to be a Frankenstein which will, in the end, bring about the undoing of our present civilization and the closure of another great cycle in the round of human progress. I am not of these, but it must be admitted that the situation is not without its possible menace, and as a member of society at large, the scientist has a clear duty in standing for a policy in the application of the results of his own work, actively in opposition to those tendencies which make for the sapping of moral and spiritual fiber.

However, in the exercise of his own functions as such, the scientist may be reassured by the reflection that, whatever may be the possibilities of misuse, nevertheless every advance in our acquaintanceship with nature and every improvement in the terms of our partnership with her does carry with it at least some potential improvement in the external conditions of life and the possible turning of another leaf in the great book within which the mysteries of human evolution are slowly unfolding into, as we hope, a larger and a fuller life.

If then, to pick up our thread of thought, there is a duty on the part of the scientist to carry on, so is there a reciprocal duty on the part of society, as the potential beneficiary, to furnish the one element which the scientist can not himself provide—at least normally in adequate degree—and that is, material support.

Coming nearer home and looking over own own vast national domain from ocean to ocean and from our northern borders to the Gulf, with our prosperity and progress during the past quarter or half century, have we as a people recognized in sufficient degree the extent to which this progress is based on advances in fundamental science? My own answer is no. We have devoted and are devoting large sums and munificent support to varied fields of applied science, but this is working with the materials which we now

have; it is carrying to fruition past labors in fundamental science; it is not adding new materials or the possibility of new combinations. I would not be understood as in any degree overlooking or minimizing the splendid work which *is* being done in our midst in fields of fundamental science, but only as urging that, in proportion to the extent to which our prosperity and progress are due to work in fundamental science and in proportion to the support which is accorded to work in applied science, we as a people should give a larger support to work of basic and fundamental character.

One of the cardinal principles of our industrial policy has been stated to be that of rapid turnover and quick returns. It may well be that, as a people, we are thinking too much of quick return in the present and too little of a foundation for continuing returns in the future. The American genius is said to be essentially practical, by which we may imply the special emphasis which we are prone to place on realizing early and definite returns on our investments and among such, early and definite returns on our investments in science and scientific effort.

But there is another and higher mode of expression for the practical instinct—a mode which takes account of the future as well as of the present, a mode which reckons with world movements rather than with those within our own borders, a mode the significance of which we can only gain by standing, in spirit, outside these movements on the checkerboard of life and from some distant point viewing the individual moves only as component parts of an intricate and slowly unfolding scheme.

If we as a people could but gain this objective viewpoint, we should realize the vital necessity of being practical through consistent, continued and adequate support of those activities in science which have for their purpose the extension of the borders of our knowledge and the addition of new building blocks for incorporation into the material structure of our civilization.

Passing from questions of responsibility and of material ways and means for carrying on work in fundamental science, let us turn to another topic bearing upon the question of efficiency within the working force of scientists themselves.

Following the trend of evolution in all phases of civilization, scientists have found it necessary to specialize more and more narrowly as the great aggregate of scientific knowledge accumulates. It thus results that the modern man of science, due to limitations of memory, of time and of aptitude, can have personal and effective knowledge of but the smallest portion of the vast domain which science now covers. It has been said that Leibnitz was the last to hold, within the domain of one mind, the learning of his day. Even if this be so, the world's work must now be carried on by the great army of us who can lay no claim to the mental endowments of Leibnitz, and even if we could, or even if he were of to-day rather than of the seventeenth century, surely no such claim could be made at the present time. The accumulation of learning, merely in the sense of the acquisition of information and its record, has become, in recent years, so enormous as to result, in a very real sense, in an embarrassment of riches.

It is true that we are served, in the study of problems in science, with a marvelous mental endowment—an endowment which gives to us at will hundreds or thousands of memory impressions bearing directly or indirectly upon the matter upon which our attention is focussed. The explanation for some phenomenon is sought. The mind sends out feelers seeking similarities or dissimilarities with other phenomena, or ties linking back the facts of observation to known and accepted elements in the great body of science. And if we are able to establish such ties or links, we say that the phenomenon is explained. In all this how admirably are we served by this endowment and how utterly helpless should we be without the aid of memory and some sense of analysis, comparison and an appreciation of resemblances and differences? But marvelous as this all is, the capacity of any one mind for dealing with one of nature's problems is, after all, subject to the limitations incident to our present stage of human evolution.

But the phenomena of nature recognize no such limitations nor do they recognize the arbitrary system of pigeonholes in which we are wont to classify our activities and store their product. Thus in the investigation of any phenomenon of nature, any other phenomenon may be significant. Any so-called law or principle or mode of action developed in one domain of science, may have some pertinent bearing in another, no matter in how apparently widely separated a domain of activity it may seem to lie.

We may be morally sure that in the domain of mathematics, for example, there are now stored away in archives, transactions and proceedings, various results, relations, principles, methods of analysis, all of which might be given useful and fruitful application in other domains of science—in physics, in chemistry, in biology, in economics, statistics, etc.—if only we could bring into the same focus in one mind the problem and the means of treatment. And the same is true with regard to physics and chemistry, for example, in relation to problems in the field of biology, geology and astronomy, and throughout the domain of applied science. But in order that the biologist, for example, concerned with some specific problem in his own field,

should be able at first hand to command all the potential resources of science at large, he must either have first-hand knowledge of the resources available in mathematics, physics, chemistry, etc., or be able to draft information from these domains, applicable to his particular problem. The first is quite beyond the capacity of the single human mind, limited as we are in time, memory and aptitude, and we have thus far developed no effective way of realizing the second.

The heart of the problem is how to bring about, in one domain of science, the application of results developed in other domains, and in particular in view of the fact that in general only small and isolated portions of any one domain can be brought sharply to focus in any one mind at any one time.

This, to my mind, is one of the most important problems pressing upon those working in the broad domain of science. Results are unquestionably now at hand in one domain and awaiting effective application in other domains—how shall we bring about some more effective measure of relief for this condition?

There is need for the organization of some superscience—some science of the use of science which shall aid in our efforts to bring into a common focus results from separate and seemingly unrelated areas of this broad domain.

There seems to be no solution ready to hand for this problem. It must come as a result of study and effort, and there will always be human limitations beyond which we can not hope to pass. Some beginning has been made in the form of organized abstracts and their publication. But this is only a beginning. Something more than an abstract is often wanted—something rather in the nature of an interpretation of a result in one domain of science into a form which may be readily grasped by those dealing with problems in other fields. Either this or else more and more must we depend on the services of those rare individuals who are able to grasp some considerable part of more than one domain of science and thus bring into focus in one mind the scattered elements of one ramifying problem. Or otherwise, we may perhaps find partial solutions in the cooperative work of two, three or four minds, representing each some special field of endeavor and concentrating directly on some one complex problem. Thus we may suppose a mathematician, a physicist, a chemist and a botanist to concentrate directly and with undivided purpose upon some one problem in the field of the latter. We do not necessarily see what part each might contribute, but it is more than probable that, in regard to such a biological problem, there might be realized a concentration of resource which would carry the problem definitely farther toward solution than through the efforts of the botanist alone. This is, in a sense, an effort to bring the content of four minds into a single focus upon a single problem.

These are only suggestions of some avenues of approach to this problem. Other avenues must be found and to an increasing degree must we give attention to this problem of the organization of a science of the use of science if we are to attempt to make effective use of the vast and ever-accumulating store of scientific information which has already reached such stupendous proportions and which is growing at an ever-increasing rate.

If among these thoughts regarding the relation of science to civilization there is any one point upon which I would wish to place some special emphasis, it is that of the responsibility of the body of workers in fundamental science, collectively and individually, charged as they are with the exercise of one of the great functions, vitally significant in and absolutely essential to the progress of civilization. I have already referred to this at an earlier point. Its importance, not only to us as scientists, but to society at large, may perhaps justify some further reference developed from a slightly different mode of approach.

Can we, in mental vision, disassociate ourselves from the stream of human progress and thus gain some measurably objective view of this vast scheme of evolution, of which we normally see ourselves only as participants? Can we climb to some high mountain peak and thence, looking over far horizons, gain some better orientation of ourselves and of our own work in reference to the great world efforts and movements about us?

As we may be able to reach some such viewpoint, we shall surely gain a clearer vision of our own place in the slowly unrolling scheme of human affairs and a sense of proportion which should enable us the better to align our own efforts with those of our fellow workers in other fields of human activity.

In any event, and as I have at an earlier point noted, we should in some such manner obtain a clearer vision of what we call our civilization, as a vast cooperative enterprise—an enterprise of which the individual elements are carried on by those assumed to be specially skilled in that particular element. At least such is the ideal. Now among those elements, each corresponding to the exercise of some one function, there are a certain number which relate to the bare necessities of existence. Thus we must have food, clothing and shelter and there must be those who provide for these basic organic needs. Then on a later level in evolutionary time, we have developed a vast array of activities, catering first to the category of luxuries but which rapidly become transformed to that of necessities—at least in our own estimation.

Thus, and only by way of illustration, means have been provided permitting us to gratify our desire for travel, far and near, over land and water and through the air, and with ever-increasing speed and comfort; or again, means have been given us responsive to our urge to communicate with our fellow, whether a neighbor or a dweller in the antipodes, and with the spoken voice or the written word and with the practical annihilation of time. Again, means wherewith to send our own produce to markets far and near over the earth's surface and to draw on the whole world's produce for our own convenience and comfort. And there have been provided as well all the complicated agencies and means suited to secure the needed degree of regulation in human conduct in a society so interdependent in its elements as has ours become; functions again needed to cater to our sense of the esthetic—to that urge to pass beyond the merely utilitarian to that which appeals to the sense of the beautiful; functions needed to meet our urge toward amusement, sport, relaxation; functions multiple in number and often interlinked in character and in exercise.

And how has the civilization of our caveman forebears or of Homeric days or of medieval times become so marvelously transformed into that of our own day? There has been one central effective means and that is the transmission by racial inheritance of the elements of the civilization of one generation to the next following. Biological inheritance provides for the transmission of biological characters, but there is a larger sense in which we may view inheritance—a sense in which the generation, the nation or the race is the individual unit and in which we view the transmission of knowledge, of achievement, of culture, from one generation to the next, as a process broadly parallel to that of the transmission of bodily or personal characteristics from parent to children. In a racial sense each generation is the child of that which precedes and we may have a racial heredity and a racial transmission of culture, of learning and of the integrated elements of civilization.

It is true that with racial inheritance through the ages, the gradient of progress has not been always continuous or uniform. At times there has seemed to be regression rather than progression. Advance has been made in periodic movements, perhaps at the moment not always forward and upward, but in the large and viewed in distant perspective, always with an ultimate gain, always with a net upward and onward trend and always again as the expression of racial inheritance.

But this implies something to inherit, and what is more, a widening field of choice over which the material to be passed on may be chosen. Progress does not depend so much upon the continuous transmission, without discard, of a gradually accumulating store of learning, culture and achievement, as upon the conscious and intelligent selection, over an ever-widening field of choice, of those elements best suited to the environment of the moment or to the racial demands of the time. In this way, progress implies examination, comparison, test, discard and selection, and exercised over this ever-widening field of choice. But who shall provide the ever-widening field of choice? Here indeed is the function of the worker in fundamental science. His the duty and the privilege to provide the basic material which shall give to civilization this ever-widening horizon of selection and which shall make possible the transmission to the coming generation—already interpenetrating with our own—some increment in quantity and some improvement in quality, of those elements which shall furnish the material basis for the civilization of which they are to be the exponents.

The obligation of the worker in these fields seems clear—it is an obligation which may be viewed collectively or individually. In no case can we escape it. The remainder of humanity are standing aside, as it were, and are waiting upon our performance of this particular function. This is our contribution to that great pool of the products of human effort. Without this particular contribution, the progress of civilization must falter and cease.

Whether individually or collectively, we may view our passage through life as that of a comet coming from afar, remaining for a time a member of our system and then passing on, whither we may not know. So we journey between two unknowns and are given but a short day in which to perform our allotted task. Like the comet from the depths of space, we pass this way but once.

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BACTERIA AND THE ORIGIN OF SPECIES

THERE is, perhaps, no field of research that has borne such an abundant harvest in recent years as the study of bacteria. While micro-organisms have been investigated from many points of view and in relation to many and diverse activities, the intimate relationship of pathogenic or disease-producing microbes to human happiness and welfare appears to have blinded not only the popular, but also the scientific mind to the broader significance of bacteria in the world.

Not many years ago we were orthodoxically taught that the atom is the indivisible unit of matter. Today we are amazed to learn of the tremendous com-

plexity of electrons that are bound together in the larger atoms! While we recognize the significance of the cell as the unit of structure and organization in the architecture of complex plants and animals, we have never felt entirely secure in the thought that the cell represents the ultimate unit of living matter. Bacteria and ultra-microscopic bodies have stood in the way of snug contentment with such a theory. Just as inorganic bodies of varying complexities are dissectible into molecules, the molecules divisible into atoms, and atoms into electrons, so also it appears that living bodies are dissectible into tissues, tissues into cells and cells into smaller units.

In the early nineties, it was shown by means of special cytological technique that bacteria-like bodies could be demonstrated universally in cells. Altmann,[1] who investigated these structures extensively, developed a theory that they represent the ultimate units of living matter, and named them "bioblasts." Altmann's theory was rejected by most biologists, although Bütschli, O. Hertwig and a few others leaned toward this hypothesis. The microscopic bodies in question have come to be known by the name "mitochondria" ("chondriosome" is also used extensively), and have been considered a product of the cytoplasm of the cell.

In 1918, Portier[2] embraced the fundamental conception embodied in Altmann's theory, namely, that the mitochondria are independent micro-organisms, and he named them "symbiotes." Portier's conclusions were based on his results in cultivating animal tissues in culture media and obtaining bacterial growths. Portier's ideas were rejected on the basis of errors in technique. In 1923, the author (Wallin[3]) published a critical analysis of Portier's researches.

Seven years ago the author began investigations on the nature of mitochondria. As these investigations progressed it became more and more evident that mitochondria are bacteria-like. In the last series of publications (Wallin[4, 5, 6]) it was shown that mitochondria can be induced to grow independently in artificial culture media.

The bald statement—that the cells of all complex plants and animals normally contain bacteria—is almost incredible in the absence of a rational hypothesis by which to explain the significance of such associations. Obviously, such a "symbiotic" association must involve a relationship of fundamental significance.

In searching biological literature for a clew to this significance, a number of phenomena were discovered which directed the path toward a solution of the problem. It was found that bacteria elaborate metabolic products that are identical with the metabolic products of the cells of complex plants and animals. Bacteria enter into diverse types of relationship with plants and animals, such as "parasitism," "symbiosis," "infection," etc. The relationships that are usually classified as "symbiosis" exhibit varying degrees of intimacy in life-relationship and tell the story of the significance of mitochondria in the cell.

In many cases, the invasion of the micro-organism results in new cell formation in the host to harbor the symbiont ("bacteriocytes," "mycetocytes," special cells in corals and other coelenterates). In the firefly and squid, luminiferous bacterial symbionts are apparently responsible for the development of "light organs" in which a number of tissues become modified in response to the bacterial invasion. A large number of examples could be cited in which there are evident morphological and physiological modifications in the host in response to the presence of micro-organisms.

The term "symbiosis," which implies "mutual advantage," is not applicable to this fundamental association. "Mutual advantage" further involves an "element of choice" on the part of the microsymbiont and the host symbiont which, obviously, can not be recognized. The author (Wallin[7]) has introduced the term "Symbionticism" to signify the underlying fundamental principle involved in these life-relationships.

Cytological literature contains a large number of references to investigations in which it is claimed that mitochondria are concerned with the *specific* activity of the cell. The validity of these findings has been questioned chiefly on the basis of an *assumed* passive nature of mitochondria. The demonstration of the *living bacterial* nature of mitochondria removes the objections that have been raised against the diverse activities attributed to them.

Briefly stated, micro-organisms unite with higher forms of life. In many such associations new tissues and new organs develop in response to the microbic invasion. Some of the "symbiotic" micro-organisms persist as mitochondria in the cell. The mitochondria are responsible for the specific activity of the cell. These demonstrable facts can lead to no conclusion other than that symbionticism, or the development of bacterial "symbiosis," is a fundamental factor in the origin of species.

This revolutionary conception of the cell, obviously, affects every department of biological science, and if true must correlate with all *established* facts in the various biological fields. The author has collected the evidence and is preparing a manuscript in which this

[1] Altmann, R., '90, "Die Elementarorganismen und ihre Beziehungen zu den Zellen," Leipzig.

[2] Portier, P., '18, "Les Symbiotes," Paris.

[3] Wallin, Ivan E., '23, *Anat. Rec.*, Vol. 25.

[4, 5, 6] *Am. Jour. Anat.*, Vol. 33; Vol. 35; Vol. 36.

[7] *Anat. Rec.*, Vol. 26.

will be presented together with a discussion of a few of the problems in biology that are affected by this new point of view.

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SCIENTIFIC EVENTS

THE FIRST SIX MONTHS OF THE INTERNATIONAL INSTITUTE OF INTELLECTUAL COOPERATION

IT is six months since the International Institute of Intellectual Cooperation was formally installed, under the auspices of the League of Nations. According to the first bulletin of its Information Section it has completed its organization and begun work on a number of problems.

Up to the present, in accordance with decisions of the council and the assembly of the League, the complete framework of intellectual cooperation has taken the following form: First, the *International Committee on Intellectual Cooperation.* This committee, appointed by the council of the League from among the distinguished scholars of various countries, meets once or twice a year to consider the more important problems of intellectual cooperation and approve their study where study seems practicable. The detail of special questions is referred to one of a series of *sub-committees,* made up partly of qualified members of the main committee, and partly of co-opted experts.

Next, the *National Committees on Intellectual Cooperation.* These committees are constituted by various countries themselves, in such fashion as to present a cross-section of the intellectual life of the country. Their function is to study national questions of intellectual cooperation and to collaborate in international questions with the central committee.

Thirty-one national committees have already been established in Australia, Belgium, Bolivia, Brazil, Bulgaria, Cuba, Denmark, Esthonia, Finland, France, Great Britain, Greece, Holland, Hungary, Italy, Latvia, Lithuania, Luxembourg, Norway, Poland, Portugal, Rumania, Salvador, South Africa, Spain, Sweden, Tchecoslovakia, the United States of America and Yugo-Slavia.

Third, *Government Delegates accredited to the Institute.* The function of these delegates is to secure to the institute the direct contact with governments necessary for the carrying out of its projects. More than twenty states have already nominated official delegates, who meet periodically as a group in Paris.

Finally, the *International Institute* itself, with seven sections.

The *General Section* has succeeded in establishing close contacts with the outstanding general international associations. The section conducts a service of documentation on intellectual questions. This service has begun to publish a selected bibliography on the international organization of intellectual life, and is preparing the ground for an international statistical survey of intellectual activities, and a repertory of international institutions and associations.

The *University Section* has been studying the international relations of universities, particularly with reference to the exchange of professors and students. It has begun to publish a *Bulletin of University Relations,* which gives an account of the international activity of universities in all parts of the world.

The *Science Section* has a wide field of action, since all the sciences are in need of agreements and research programs conceived on an international scale that will economize effort by avoiding duplication of work.

The section has prepared an agreement among libraries in all parts of the world for an international information service available to the public: 400 have actually responded to the questionnaires sent out by the section. It is also studying projects for an international lending library, the reorganization of analytic bibliography in the physical sciences, and the creation of a permanent international bureau of meteorology. The section has been in close touch with the proceedings of scientific congresses. It has begun the publication of a *Bulletin of International Scientific Relations.*

There are in addition sections of law, literature, art and information.

ENGLISH VITAL STATISTICS

THE Registrar-General's *Statistical Review* of England and Wales for 1924 has been issued. According to an abstract in the *British Medical Journal,* the number of deaths (473,235) is the smallest registered since 1867, when the population was only 56 per cent. of that estimated for 1924. They correspond to a rate of 12.2 per 1,000 of the estimated population, but when standardized this rate is reduced to 10.7. The standardization was effected by comparison with 1901, when the population included relatively few infants and old people; it formed, therefore, a standard exceptionally favorable to low mortality and accordingly yielded comparatively low standard rates all round. To correct any wrong impression thus produced and to provide standard rates comparable with those of other countries the standards recommended by the International Statistical Institute were used, when the rate was increased from 10.7 to 12.0 per 1,000. The standard rate of 10.7 was less than any returned prior to 1924, when the low record of 10.3

was reached. The increase of mortality, which applied equally to each sex, occurred entirely in the first quarter of the year, when the death rate rose from 13.2 per 1,000 in the previous year to 16.6. The rate for the second quarter was lower than for any of the previous nine years, except 1921, and those of the third and fourth quarters were the lowest yet recorded. The excess in the first quarter occurred chiefly in March and was largely due to influenza, but the rate was high for a number of other diseases also, and it would appear that the conditions during March were such as to hasten the advent of death when impending from many causes not otherwise affected by season. The rate of infant mortality was 75 per 1,000 births, and was the lowest recorded, except in 1923, when it fell to 69. In a section on the distribution of infant mortality it is shown that the rates for the county boroughs and for the North of England are, as usual, in considerable excess, the highest rate being 99 for the northern county boroughs, and the lowest, 51, in the rural districts of the south. Taking the country as a whole, the fall of 6 per cent. as compared with the preceding quinquennium was accounted for by a decline in the number of deaths attributed to diarrhoea, congenital debility and convulsions. There was an increase from bronchitis and pneumonia. The reduction of mortality at ages 1 to 5 has been greater than in that of infants. As was pointed out in the report for last year, this is the period of life at which susceptibility of mortality to environment is greatest, so it is probable that improvement in the conditions under which the children were living has been the main factor in bringing about this remarkable change. For this improvement the fall in the birth rate may be largely responsible, but if so it "can not be expected to continue for long at the recent rate, for the birth rate, though it may continue to fall, can not long do so at the present rate consistently with national survival."

GEOGRAPHIC NAMES

GEOGRAPHIC names established by the expedition of the California Academy of Sciences to the Revillagigedo Islands, Mexico, have been adopted by the United States and Mexican governments as follows:

ANGULO ROCK. A small, outlying, flat-topped rock immediately northeast of Asuncion Island, Lower California. It is named for Captain Victor Angulo, commander of the Mexican National Patrol vessel, *Presidente*.

MOUNT GALLEGOS. The highest mountain on Clarion Island of the Revillagigedo group. Chart No. 1688 of the United States Hydrographic Office, gives the elevation of this mountain as 1,100 feet. It is named in honor of the late Professor Jose M. Gallegos, explorer for the Government of Mexico and a member of the party which, in 1925, explored this mountain.

MOUNT EVERMANN. The central peak of Socorro Island of the Revillagigedo group. Named for Dr. Barton Warren Evermann, the distinguished director of the California Academy of Sciences and the organizer of this and many other expeditions in which the academy has actively cooperated with the Government of Mexico.

GRAYSON'S COVE. There is a little cove at the west end of Cornwallis Bay, Socorro Island, as shown on Chart No. 1687 of the United States Hydrographic Office. Here, in 1867, Colonel A. S. Grayson's sloop was wrecked. It is the only known supply of fresh water on the island and the suggestion has been made that it be so marked on future charts.

POINT OLD MAN OF THE ROCKS. This name was given by Colonel Grayson to the point of rocks which formed the eastern boundary of the little cove where he found fresh water.

ASH HEAP. At the south end of San Benedicto Island the highest elevation is attained, 975 feet. This elevation or peak is composed almost entirely of soft volcanic ashes, hence the name.

HERRERA CRATER. The central peak of San Benedicto Island is indicated on Chart No. 1687 of the United States Hydrographic Office as being 683 feet high. This peak is named in honor of Professor Alphonso Herrera, the director of the National Museum of Mexico. Professor Herrera took an active part in the expedition.

VISIT OF THE AMERICAN CHEMICAL SOCIETY TO PRIESTLEY'S GRAVE

To mark the one hundredth anniversary of the discovery of oxygen, seventy-four American chemists visited the former home of Priestley on the banks of the Susquehanna in August, 1874, and at that time the association was formed which became two years later the American Chemical Society. At the time of the meeting of the American Chemical Society in Philadelphia on September 5, there will be a second visit to the home and grave of Priestley.

We learn from an article on the subject by Dr. Gerald Wendt in *Industrial and Engineering Chemistry* that only three of the original group survive. Of these Dr. S. A. Goldschmidt, of New York City, a member of the society for fifty years, and Professor A. A. Breneman, also of New York iCty, are expected to be present. Dr. F. W. Clarke, of the U. S. Geological Survey, is at present in England. Though only two of the original seventy-four can be present, there will be hundreds of their scientific heirs who will make the pilgrimage to mark the double anniversary. Some of them will be looking forward to their part in the next great pilgrimage in 1974.

Hosts on this occasion will be Mrs. Frances Priestley Forsythe, great-granddaughter of the founder of modern chemistry; the Central Pennsylvania Section of the American Chemical Society, in whose territory the town of Northumberland lies, and the G. G. Pond

Memorial Association. This last is composed of alumni of Penn State, former students of Dean Pond, who answered his appeal six years ago and purchased the old mansion. It was already a century and a quarter old and had fallen on evil days, having been used during the war as a boarding house for immigrant labor. It was purchased at public auction to save it from entire destruction. It has been reconditioned and a fireproof museum, designed by Professor A. L. Kocher, an authority on early Pennsylvania architecture, has now been erected on the lawn, to house a complete collection of Priestley's original laboratory apparatus and other personal effects. Much of this is still in existence, due to the devotion of Mrs. Forsythe, of Dr. Edgar F. Smith and others, and will be permanently on display in this museum.

Northumberland was a frontier settlement when Priestley arrived in 1794, beautifully situated under high hills at the junction of the east and west branches of the Susquehanna River. It is 160 miles from Philadelphia, but he chose it because "nothing can be more delightful or healthy than this place," while Philadelphia seemed "unpleasant, unhealthy and intolerably expensive." To-day it is an industrial town of several thousand people. The house stands directly on the banks of the east branch of the river, facing the city of Sunbury just opposite. Near by is the brick church, built in 1834, which still houses the Unitarian congregation organized by Priestley in 1794. Half a mile away is the town's only cemetery where Priestley lies with his wife and seventeen descendants, two of whom were also "Dr. Joseph Priestley."

The ceremonies will be brief. There is no room at the grave for exercises so that the pilgrimage itself and perhaps the laying of a flower will constitute the simple homage of each individual chemist. The special train is scheduled to arrive at one o'clock and the visit to the grave will be made first. There will then be time to examine the Priestley house, including the spacious room in the ell which was used by Priestley as a laboratory, and the new museum containing his original apparatus. The meeting will convene on the lawn at 2:15 under the two tall pines planted by Priestley himself. The porch of the house will be used as a platform.

Dr. S. A. Goldschmidt, the only surviving charter member who was present at the 1874 meeting, will give an account of that meeting. Dr. Wm. H. Walker, formerly of the Massachusetts Institute of Technology, who taught at Penn State with Dr. Pond in the early nineties, and was active with him in the effort to preserve the Priestley house, will speak on the history of the house, and Dr. C. A. Browne, chief of the U. S. Bureau of Chemistry and chairman of the American Chemical Society committee on the historical program for the fiftieth anniversary, will speak on Priestley's life in Northumberland and on the relics exhibited. The meeting will be less than an hour in length and the special train will leave for Philadelphia at about 3:30.

SCIENTIFIC NOTES AND NEWS

DR. FRANK R. LILLIE, professor of embryology at the University of Chicago, has resigned the directorship of the Marine Biological Laboratory at Wood's Hole, which he has held since 1908. He remains president of the Board of Trustees. Dr. M. H. Jacobs, of the department of zoology of the University of Pennsylvania, has been elected director of the laboratory to succeed Dr. Lillie.

ON the occasion of the recent meeting of the British Association for the Advancement of Science, the degree of doctor of science was conferred by the University of Oxford on Dr. Henry Fairfield Osborn, of the American Museum of Natural History.

THE citizens of Milan, Ohio, the birthplace of Thomas A. Edison, plan to raise money to buy a 200-acre tract for a park as a permanent memorial to Mr. Edison.

IN the plans for celebrating the centenary of Ottawa, the fact that Marquis wheat was originated at the Canadian Government's Central Experimental Farm by one of its workers, is to be emphasized. By this discovery in 1904 Dr. Charles E. Saunders, who was then the government cerealist, has increased not only the agricultural wealth of Canada by many millions of dollars, but also that of the hard wheat-growing area of the United States, for it is said that 90 per cent. of the spring wheat grown in Canada and 60 per cent. of that produced in the United States is Marquis.

THE colleagues of the well-known Danish physiologist, Professor August Krogh, have made his fiftieth birthday the occasion for offering to him their felicitations and homage in the form of a volume entitled *Physiological Papers*.

THE Bavarian Academy of Science has elected as corresponding members: Dr. Harald Bohr, professor of mathematics at the Technical Institute at Copenhagen; Dr. Niels Bohr, professor of physics at the University of Copenhagen, and Dr. Hans Strasser, professor of anatomy and director of the anatomic institute of the University of Bern.

Nature states that the Council of the National Institute of Agricultural Botany has awarded the Snell Memorial Medal for the year 1925 to Dr. R. N. Salaman. The medal is given annually to mark distinguished work in the sphere of potato husbandry,

and has been awarded to Dr. Salaman in recognition of his eminent services in the study of the problems connected with the breeding and the diseases of potatoes. The medal will be presented to Dr. Salaman at the public inspection of the trials at the Potato Testing Station, Ormskirk, on August 19.

THE council of the Royal Meteorological Society has awarded the Howard Prize for 1926 to Cadet B. W. Harman, of H.M.S. *Worcester,* for the best essay on "The Causes and Distribution of Fog in the North Atlantic."

DR. OLIVER J. LEE, a member of the staff of the Yerkes Observatory, has resigned.

THEODORE A. WERKENTHIN has recently resigned his position as head of the science department of Queens College, Charlotte, N. C., and has again become associate with the Solar Refining Company, Lima, Ohio, after a year's leave of absence.

C. H. HERTY, JR., formerly research associate connected with the Massachusetts Institute of Technology at the Bethlehem Steel Co., Lackawanna, N. Y., now has charge of the work on physical chemistry of steel-making at the Pittsburgh Experiment Station of the U. S. Bureau of Mines.

DR. CHARLES TERZAGHI, special lecturer on soil mechanics for the Massachusetts Institute of Technology in 1925–26, has accepted temporary appointment with the Bureau of Public Roads, as research consultant on subgrade soil investigations.

DR. ERNEST MARSDEN, assistant director of education for New Zealand, has been appointed permanent secretary of the new Industrial and Scientific Research Department.

DR. S. C. HARLAND, professor of botany and genetics at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, has been appointed head of the department of genetics of the cotton research station of the Empire Cotton Growing Corporation.

THE Cheney Research Fellowship at Yale, which was established for the study of the chemistry of natural silk, will be held next year by Dr. Floyd S. Daft, who will be able to carry on his investigations at the Carlsberg Laboratory in Copenhagen, Denmark, under the direction of Professor S. P. L. Sorensen.

DR. EDWIN G. CONKLIN, professor of biology at Princeton University, who has visited the Orient and made a trip around the world under the auspices of the Rockefeller Foundation, arrived in New York on Saturday, July 31, on the *Aquitania.*

DR. GARY N. CALKINS, professor of protozoology at Columbia University, sailed for Europe on August 1 to take up work as director of the American University Union at Paris. Dr. Calkins will return to New York about January 15 for three months when he will leave again for Paris to stay until October.

AT Porto Rico, Dr. Robert A. Lambert has taken up his work as director of the new School of Tropical Medicine and Dr. George C. Payne has succeeded Dr. Rolla B. Hill as director for Porto Rico of the International Health Board of the Rockefeller Foundation.

DR. CHARLES H. FRAZIER, professor of surgery in the University of Pennsylvania School of Medicine, has left for a five months' trip in China. He will deliver an address before the "Chinese Medical Society" at Peking in September.

DR. EDWARD C. KENDALL, of the University of Minnesota, sailed for Stockholm on July 17, where he will attend the International Physiological Congress.

DR. R. S. BASSLER, curator of stratigraphic paleontology in the U. S. National Museum, sailed on August 7 for a two months' collecting trip in Europe, in order to further his studies on the micropaleontology of various groups of fossils. Dr. Bassler will also visit various museums to study collections and methods of installation.

PROFESSOR VITTORIO ASCOLI, director of the medical clinic in Rome, and Professor G. Alessandrini, director of the bacteriologic institute of that university, have been invited by the government of Argentina to represent Italy at the medical congress to be held in Buenos Aires. They will speak at the congress on the results of Italian studies on malaria.

PROFESSOR MAXIMOV, of Leningrad University has been invited to deliver a series of lectures at Chicago, New York, Philadelphia and other American centers on his recent researches on the combat of droughts.

THE Royal Academy of Sweden has appointed a committee to organize a celebration of the 350th anniversary of the foundation of Tycho Brahe's Observatory, Uraniborg, on the Island of Huen, which now belongs to Sweden.

DR. JOHN FRANCIS HALL-EDWARDS, who devoted twenty-eight years of his life to experimenting with and perfecting the X-ray, died on August 7, at Birmingham. He was one of the pioneers in X-ray investigation and continued the work despite the heavy handicap of the loss of both hands through burns

SIR WILLIAM RIDGEWAY, Disney professor of archeology at the University of Cambridge, died on August 12.

Nature reports the following deaths: Dr. R. H. Clarke, formerly demonstrator of physiology at St.

George's Hospital, London, author of an atlas of sections of the brain of the cat and monkey, and joint author with Victor Horsley of a number of papers in *Brain*, on June 22, aged seventy-five years, and of M. Albert Viger, for thirty years president of the French National Horticultural Society, and seven times minister of agriculture, on July 8.

THE New York Cancer Association, of which Dr. Isaac Levine is director and Dr. George D. Stewart, professor of surgery at New York University, is chairman of the executive committee, plans to establish in New York City a laboratory for the study of cancer, with twelve research workers and twenty-four technical assistants. A budget of $108,000 for the first year has been arranged.

A SITE for a botanical garden, comprising forty-four acres on Strawberry Hill, has been offered to the City of Stamford, Conn., by Mrs. Albert Crane in memory of her late husband. Mrs. Crane also plans the gift of $50,000 outright for the preparation of the land and a trust fund of $100,000, the income to be used in the maintenance of the land as a botanical garden. Dr. William T. Hornaday, who recently resigned as director of the New York Zoological Park after a long term of service, has made a survey of the land and pronounces it excellent for a botanical garden. Dr. Hornaday, now a resident of Stamford, is much interested in the project and will lend his aid in the preparations, if it is accepted by the city. In his report to Mrs. Crane, he finds that about $20,000 will be needed annually to maintain the land in addition to the income from the trust fund. The city is asked to agree to furnish this sum yearly in consideration for the gift of the park. Mrs. Crane would keep her home and about four acres of land on the site during her life-time.

THE London Mathematical Society has begun publication of a second periodical, in addition to its *Proceedings*, to be called *The Journal of the London Mathematical Society*. It will contain proceedings of meetings, abstracts, obituary notices, etc., besides short original articles.

Nature reports that the Air Ministry of Great Britain has announced that five hundred aircraft apprentices, between the ages of 15 and 17 years, are required by the Royal Air Force for entry into the Schools of Technical Training, Halton, Bucks and Flowerdown, near Winchester. They will be enlisted as the result of an open and a limited competition held by the Civil Service Commissioners and the Air Ministry respectively. Successful candidates will be required to complete a period of twelve years' regular Air Force service from the age of 18 years, in addition to the training period. Full information regarding the aircraft apprentice scheme, which offers a good opportunity to well-educated boys of obtaining a three-years' apprentice course of a high standard and of following an interesting technical career, can be obtained on application to the Secretary, Air Ministry, Kingsway, London, W.C.2.

HITHERTO unknown archeological ruins, called Macanxoc, meaning "You can not read it," were found by E. S. Thompson and J. Charlot, of the Carnegie Institution, on May 24, according to information reported to Washington by Dr. Sylvanus G. Morley, in charge of the extensive diggings centered at Chichon Itza. Macanxoc is said to be the religious and ceremonial center of Coba, a large provincial Old Maya Empire City, fifty miles east of Chichen Itza. Inscriptions on stelae have been found that date from 364 to 413 A. D. From the style, sculpture and dates of the hieroglyphics on the remains, it is supposed that Macanxoc is the oldest center of Maya civilization thus far known to Yucatan. The most brilliant Maya paintings so far known and the best preserved painted serpent heads yet found were unearthed recently in the Temple of the Warriors at Chichen Itza by E. H. Morris. Remains of a serpent column temple decorated with these works of art were revealed when a corner pyramid was excavated.

UNIVERSITY AND EDUCATIONAL NOTES

THE Presbyterian Hospital, built at a cost of $6,000,000, which when completed will be the general hospital for the proposed new medical center of the University of Pittsburgh, provides for a hospital of 600 beds, to be erected on the "knoll" now occupied by the Faculty Club. It has been announced that the Eye and Ear Hospital will join in the medical center and erect a $1,000,000 structure opposite the new children's hospital on the university's site. Plans are being considered for the affiliation of the Montefiore and another special hospital with the medical center.

DR. H. R. KRAYBILL, formerly biochemist of Boyce Thompson Institute for Plant Research, has been appointed professor of agricultural chemistry in Purdue University and state chemist and seed commissioner.

GLENN V. BROWN, who received his Ph.D. from the University of Pennsylvania, has been made associate professor of chemical engineering in the college of applied science at Syracuse University.

J. C. WARNER, of Goshen, Ind., a graduate of the University of Indiana, has been appointed instructor in chemical engineering at the Carnegie Institute of Technology.

AT the University of Minnesota promotions to full professorships include: Darrel H. Davis, geography; Wilson D. Wallis, anthropology, and Jacob O. Jones, engineering. Promotions to associate professorships are: William S. Cooper, botany; John H. Van Vleck, physics; George C. Priester, engineering, and George H. Montillon and Lloyd H. Reyerson, chemistry.

PROFESSOR G. VIALE, of the chair of physiology at the University of Sassari, Italy, has been appointed to a similar chair at the University of Buenos Aires.

DR. J. S. DUNKERLY, lecturer in parasitology at the University of Glasgow, has been appointed professor of zoology and director of the museum at the University of Manchester.

DR. A. W. BORTHWICK, formerly lecturer in forest botany at the University of Edinburgh and afterwards serving on the Forestry Commission, has been appointed to the new chair in forestry at the University of Aberdeen.

DISCUSSION

THE MOST PROBABLE VALUE OF CERTAIN BASIC CONSTANTS

THE first volume of the new International Critical Tables (I. C. T.) contains, on page 17, a list of nine so-called basic constants, and on the following page, a list of twenty-one constants derived from the nine basic constants by direct substitution in certain accepted formulas. In other words, each of the twenty-one derived constants is some function of two or more of the basic constants.

Now it sometimes happens that one can measure a certain function of two or more quantities with a greater precision than that attainable in the measurement of each separate quantity. The numerical value of such a function thus constitutes a condition which should be given due weight, in adopting a *system* of values of the separate constants. The constants given in the I. C. T. were adopted early in the year 1923, and it is questionable whether at that time it was possible to devise a thoroughly satisfactory system. The situation is much better at the present time, as will appear from the following discussion. This relates to the values only of e, e/m, h, and c, *i.e.*, those constants which are of direct concern in spectroscopy.

Because of the general acceptance of the values of 4.774×10^{-10} es for the electronic charge, and 2.9986×10^{10} cm sec^{-1} for the velocity of light (as given in the I. C. T.), we shall tentatively assume these to be correct. We may then calculate h from the observed ratio h/e, since this is now the most accurate method for obtaining the value of the Planck constant.

E. O. Lawrence (*Phys. Rev.* 27, 809, 1926) by the method of critical potentials obtains 10.399 ($\pm$ 0.007) volts for the ionization potential of mercury. From the quantum relation we have

$$h/e = \text{volts} \times 10^8/(c^2 \times \text{cm}^{-1}),$$

and with cm^{-1} = 84,178 for mercury, one obtains

$$h/e = 1.3739 \ (\pm 0.0009) \times 10^{-17} \text{ erg sec es}^{-1},$$

and therefore

$$h = 6.559 \ (\pm 0.0044) \times 10^{-27} \text{ erg sec.}$$

The indicated error in the voltage and in h/e is the purely experimental error, while that in h is consequently the probable error *exclusive* of the error in e. (Lawrence gives $h/e = 1.3735$, and $h = 6.550$. Even if 1.3735 were correct, the resulting value of h would be 6.557.)

The second method of obtaining h/e is by means of the continuous X-ray spectrum. The most accurate result, by Duane, Palmer and Yeh (Proc. Nat. Acad. Sci. 7, 237, 1921) leads to $h = 6.5562 \pm 0.0050$, where again the indicated error (deduced by the writer) is exclusive of the error in e. But these investigators used 3.028 for the grating constant of calcite, while 3.029 is now considered the best value. (See, for instance, Compton, Beets and De Foe, *Phys. Rev.* 25, 625, 1925.) Making this correction one obtains $h = 6.5586$, in extremely good agreement with the Lawrence value.

The value of h adopted by the I. C. T. is 6.554. This is the value calculated by the writer (*Phys. Rev.* 14, 361, 1919) in a general discussion of the most probable value of this quantity. On the basis of later work the writer (*Nature* 111, 811, 1923) gave 6.557, with a stated probable error of a few units in the last place. (The I. C. T. give 0.001 as the total probable error in h. This is certainly far too small.) The chief source of error, as previously noted (*loc. cit.*), is that in Millikan's value of e (4.774 ± 0.005) since this quantity occurs to some positive power in every determination of h. The above new results for h indicate that the most probable value is now somewhat higher, and upon the basis of all available data, I now judge 6.560 to be a better value, with the probable error as before. This value evidently satisfies the known values of h/e within limits of error.

A well known relation between c, e, e/m, and h, is that given by the Rydberg constant for infinite mass

$$N_\infty = (2\pi^2 \times e^5)/(h^3 \times c^2 \times e/m) \text{ cm}^{-1},$$

where e/m is in em units. Using 109,677.6 cm^{-1} as the most probable value of the Rydberg constant for hydrogen, and assuming $e/m = 1.760 \times 10^7$ em for the evaluation of the small corrective term (59.7 cm^{-1}),

one obtains $N_\infty = 109{,}737.3 \pm 0.3$ cm^{-1} as the most probable value. (The writer's older value—*Phys. Rev.* 17, 589, 1921—was 109,736.9.) With this new value of N_∞ and the adopted values of h, c, and e, one then obtains $e/m = 1.757 \times 10^7$ em, as the necessary consistent value. (The I. C. T. value is 1.769.)

Now I have suggested (*Nature, loc. cit.*) that the most probable value of e/m is 1.761 ± 0.002, from a study of the complex Zeeman effect, by H. D. Babcock. The apparent discrepancy here is easily removed by a slight alteration in e, which occurs to the fifth power in N_∞. Thus with Babcock's value of e/m, a value of $e = 4.776$ would satisfy the known relation. As a compromise we shall adopt $e/m = 1.760$, giving 4.7755 for e. One thus obtains the following *system* of values for these fundamental constants which not only satisfies the known relations between these quantities, but which will agree also within limits of error with the most probable value of *each* constant, as determined independent of any such relations. These values are

$$e = 4.7755 \times 10^{-10} \text{ es.}$$
$$c = 2.9986 \times 10^{10} \text{ cm sec}^{-1}.$$
$$h = 6.560 \times 10^{-27} \text{ erg sec.}$$
$$e/m = 1.760 \times 10^7 \text{ em.}$$

Some of the resulting derived constants are

$$h/e = 1.3737 \times 10^{-17} \text{ erg sec es}^{-1}.$$
$$hc/(e \times 10^8) = 4.1191 \times 10^{-15} \text{ volt sec.}$$
$$hc^2/e = 12{,}351 \text{ volt Å.}$$
$$e \times 10^8/(hc^2) = 8096.2 \text{ volt}^{-1} \text{ cm}^{-1},$$

where in each case absolute volts are to be used (one international volt = 1.00043 absolute volts). The above adopted values differ somewhat from those given by the writer in a recent paper to the Physical Society (Mills College, June, 1926). The later discovery of a numerical error has quite changed the situation, and has led now to the adoption of several new values as just given.

In this connection it is interesting to enquire whether any of the previous investigators have made the correction from the international to the absolute volt. If the published voltages are in international volts, then the value of h derived from the h/e ratio should be raised four parts in 10,000, and since voltage enters into most of the accurate determinations of h, it is likely that the most probable value is more nearly 6.562. In this case e must be still higher, or e/m lower, or both.

The values of the fundamental constants given in the I. C. T. lead necessarily to the quoted value $N_\infty = 109{,}300$ cm^{-1}. The tables, however, neglect to state that this value deviates radically from the known experimental value of 109,737, and this latter value does not appear in the first volume of these tables. The writer wishes to emphasize this matter, and to express the hope that no one will use this incorrect value of 109,300.

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IN the preceding article, certain remarks concerning International Critical Tables seem to indicate that Professor Birge has missed the significance of the particular table to which he refers. This suggests that others may do likewise. Also there is some danger that one may acquire from that article an incorrect impression regarding International Critical Tables. For these reasons, a few words of explanation seem desirable.

That table was not intended to furnish information regarding the most probable value of any of the quantities contained in it, but solely to inform the user of International Critical Tables of the bases upon which rest those data which are unaccompanied by a specific statement bearing upon the subject. Consequently, this table appears anonymously, at the beginning of the work, and in a section of which the first paragraph, entitled "Bases of Data contained in I. C. T.," explains the purpose and the limitations of the table. In particular, it is stated; "Although the accepted values were close approximations to the best values at that time available, it was not claimed that they were such best values." The table was prepared at the very beginning of the work upon International Critical Tables and for the purpose of providing the numerous cooperating experts with a common basis to which were to be referred all data except those for which another basis was plainly necessary. The experts were instructed to confer with the editorial office regarding such exceptional cases, and to include in each report an explicit statement regarding each basic datum which differed from the corresponding accepted constant.

In the preparation of that table, any one of three courses might have been followed. (1) That value, which seemed to be esteemed the best by specialists in the field concerned, might have been selected independently for each quantity. Obviously, values so selected would have been more or less inconsistent, one with another, and, consequently, there would have arisen cases in which data reduced on the basis of one would differ from those reduced on the basis of another, although the two sets of data were derived from the same identical observations. This would have been unsatisfactory. (2) An attempt might have been made to set up a system of values which would give the best fit in every case. The establishing of such a system would have been most excellent; probably it could have been done, but it would have necessitated a thorough study of the entire field, and

would have unduly delayed the work. (3) A minimum number of those quantities, which, by a fairly general consensus of opinion, are to be considered of a basic character, might have been selected as basic; for each of these, such a value as seemed to accord with the more trustworthy opinions of appropriate specialists might have been selected; and from these, the values of other quantities might have been computed. This procedure gives a self-consistent set of values, and is the one which was followed. The computed values would have accorded with the experimental ones if the computational equations and the values chosen for the basic quantities had been correct; but in certain cases, such as the Rydberg constant, they did not. The failures arose mainly from the fact that the values assigned by the specialists, to the four quantities, c, e, h, e/m, were mutually inconsistent, although generally, each specialist concerned himself with all four. As it happened, the values "accepted" for these four quantities agreed with those advocated at that time by Professor Birge, except in the case of e/m; for that, an appreciably smaller value was accepted. It now appears that the principal error is in that quantity, and that a still smaller value should have been assigned to it. It was in view of the uncertainties in the values of the basic quantities and of the existence of discrepancies between certain of the derived constants and the best experimental determinations of the same constants, that provision was made for permitting a cooperating expert to use another value whenever such a course seemed justified.

In view of the purpose and the setting of this table it seemed unnecessary to append a note giving the most probable value of each of the several quantities, as such values should be sought elsewhere in International Critical Tables.

N. ERNEST DORSEY,
Associate Editor,
International Critical Tables

THE NEED OF AN ENLARGED LIST OF BOTANICAL NOMINA CONSERVANDA

IN SCIENCE for April 16, Dr. Shear and Dr. Clements, under the title, "The Condition and Needs of Systematic Mycology," state that "two great deterrents to students, as well as to general botanists and other plant scientists, are the lack of uniformity and stability in the use of Latin names and the endless subdivision and duplication of genera and species"; they urge that the quickest and simplest method of bringing order out of the present chaos of names is to prepare a list of fungi following general usage.

Such a list seems to be as much needed for the higher plants as for the fungi, and especially for plants of economic and horticultural importance. The Vienna and Bruxelles Congresses adopted a list of genera. A list of genera and species, if it could be formed in some way so as to secure international acceptance, would be for practical purposes an extension of "nomina conservanda," names conserved until revised as a whole.

For the seed-bearing plants the one comprehensive list is the "Index Kewensis," prepared at the suggestion of Charles Darwin. In the original form it was intended to include all published names and to refer synonyms to accepted names. For the genera and families, Bentham and Hooker's "Genera Plantarum" was followed; the specific names were taken according to the "Kew rule," that is, the earliest under the accepted genus. In the successive supplements the plan of evaluating synonyms has been found increasingly impracticable; to list names from all parts of the world and reduce them to a unified system is not at present possible. Thus, the *Index Kewensis* has become more and more a list of names and not a list of plants, a transformation hastened, perhaps, by the adoption of the "Vienna rule" of using the earliest specific name regardless of genus.

In recent years "Standardized Plant Names," limited to horticultural and economic plants, follows in the main Bailey's "Standard Cyclopedia of Horticulture." The practical importance of the names included makes it of general interest; the principle of names "standard until revised" might perhaps serve botanists as well as horticulturists. For botanic gardens a greater uniformity in nomenclature would much simplify their work.

It would seem that certain changes in arrangement of "Standardized Plant Names" would be desirable for possible international support:

(1) An international botanical edition should be in Latin, omitting English names.

(2) Varieties should be omitted, at least at first, with a view to reaching agreement on main lines before trying to decide the innumerable questions as to varieties.

(3) Authorities should be added to the names.

(4) The genera should be arranged under families, with index of genera referring these to the families. Families are now used to some extent in "Standardized Plant Names," under Ferns, Cacti, Grasses, etc. This plan could easily be extended to all names, with the result of making the whole work more readily available to criticism, so as to gradually correlate with the best botanical opinion.

Such a book would be considerably smaller than the present edition.

In a recent article Dr. A. S. Hitchcock (*American Journal of Botany*, XIII, p. 291) comments on the

fact that "there is an insistent demand among botanists, especially among the non-taxonomists, that plant nomenclature should be unified and stabilized . . . the non-taxonomist wishes to have one name for one plant, constant, invariable, and everlasting throughout the world." We do not find that the "everlasting" part is an essential requirement. But if approximate *uniform names* do appear to be so universally desired, why not meet this requirement by the best means at hand? This would relegate to less importance the intricacies of application of the rules of nomenclature.

ALFRED GUNDERSEN

BROOKLYN BOTANIC GARDEN

NEW YORK CITY AN ASEISMIC AREA

DR. C. A. REEDS' article in SCIENCE of April 23, 1926, and other published statements of the same tenor prompt one to say that it is somewhat dangerous to call any district an aseismic area. Even if the evidence of aseismicity is based on records from a seismograph, caution is needed, as the majority of the world's seismographs are adjusted for recording distant earthquakes and make exceedingly poor records of small local earthquakes if they record them at all. Apparently the American Museum of Natural History seismographs failed to record the shake of June 8, 1916, that was felt in Eastchester, Mount Vernon and Scarsdale with estimated intensities varying from 3 to 5 on the Rossi-Forel scale. I have faint recollections of other shakes having been reported from the environs of New York City, but can not place my hands on the facts at present. Doubtless other tremors occur but are unnoticed on account of traffic. Earthquakes are not at all uncommon in the lower Mohawk valley.

R. H. FINCH

HAWAIIAN VOLCANO OBSERVATORY

SCIENTIFIC BOOKS

Aristotle. By W. D. ROSS, M.A., fellow and tutor of Oriel College; deputy professor of moral philosophy in the University of Oxford, Charles Scribner's Sons, New York, 1923.

Aristoteles: Grundlegung einer Geschichte seiner Entwicklung. By WERNER JAEGER, Berlin, Weidmannsche Buchhandlung. 1923.

THOUGH what other cause lies back of it is still a matter of conjecture, it is doubtless due to the revival of classicism among all the cultured nations of the world that two works on Aristotle, the man, of such impressive merit should have appeared, one in Germany and one in England, almost simultaneously. One represents the consequential and ordered study of a German savant pursuing, only as a German professor can, the intricacies of the evidence of Aristotle's mental development. The other book is by an Oxford don, who has lately given the world probably the best text of Aristotle's "Metaphysics" which the world of science has ever seen. Ross's book is rather a discussion of Aristotle's different works from the standpoint of a critic, but it does not lack a tribute to his personality. It does not exhibit, however, so much how his mind, as every thinking man's mind in step with his age and in accordance with his environment does, underwent its evolution. This is the striking feature of Professor Jaeger's work.

Both Ross and Jaeger have gone far and done much to show us how sympathetic Aristotle was towards platonic philosophy and how loyal he was to his master during the years of his long nonage and long after it, but the modern testimony even as to this is not always so unqualified. It is Ross who says that in distinction from his scientific work in natural philosophy there is no page of his purely philosophical works which does not bear the impress of Plato. To this opinion Jaeger still more emphatically commits himself, and he supports it by an overwhelming array of citation in parallel columns which quite negative the assertion of Mabbott in a recent number of the *Classical Quarterly* that Aristotle was unsympathetic and superficial in his treatment of Plato. It is true, Ross admits, that even while in the Academy, in the first decades of his life, he carried his studies in natural philosophy far beyond what the school could teach him and he seems to have lectured there on rhetoric. Jaeger offers good evidence that pursuing this line and joining with Plato in opposition to and rivalry with Isocrates he subsequently developed the doctrines of his ethics.

After Plato's death his stay at the Academy, and indeed in Athens during the dominance of Demosthenes in politics, became impossible or at least uncomfortable. He took refuge at Assos, and it was along the coasts of Asia Minor that he pursued his study of biology and laid the foundation of that knowledge which still astounds modern scholars. He fished for specimens at Mitylene and in the lagoon of Pyrrha. His father had been a physician at the court of the Macedonian kings. He himself was about the age of Philip and became the tutor of Alexander at Pella when the latter was about thirteen. As the latter swept the enemies of himself and his father out of the mainland and the islands of Greece preparatory to his meteoric career in Asia, Aristotle returned to Athens in the rising Macedonian flood of empire and in 355–4 rented some buildings and established a school, the Lyceum, in a grove near the Ilissus where Socrates had wandered and talked not of science

but of love with Phaedrus. Here then it was that Aristotle must have first tried to get the gilded dandies of Athens to dip their fingers in the abdominal cavities of newts and lizards and crabs.

It is at first chiefly through the fragments of the lost dialogues of Aristotle that Jaeger traces the platonism which filled the mind of the young Aristotle and which he never entirely lost, but whatever his later guidance may have been the country lad of Stagira must have brought to Athens some knowledge of animal life from the marshy shores of Chalcidice, some glimmer of medical science from his father's surgery. In contact with these things, probably, he remained until he was seventeen, when his father died. In most boys of forward minds this is the age when the impressions made are the deepest and most lasting. Out of them the biology of the middle years may have emerged when he lectured at the Lyceum, near the Ilissus, and told the young fops fresh from the high life of the Athenian palestra that systematic science was of two kinds, one only, however, being scientific knowledge and the other educational knowledge—research science and class-room science, perhaps, he had in mind. The play of the mind in metaphysics, the wonders of the heavens above were all of them man's interest, but not less the marvels of life itself, he says in his "Parts of Animals." We must not revolt with childish aversion from the examination of the humblest animals. Every realm of nature is marvelous. I doubt if the roots of this can be found in his early platonism, and Jaeger does not suggest it, but when he began to stand on his own feet at the zenith of his manhood, he may well have harked back to the days of his boyhood when the marvels of life along the Aegean made their impression before the magnetism of Plato's personality drew him into the circles of academic thought, into metaphysics and the science of the soul.

This influence, possible enough at least, is not emphasized, but from the time he entered the Academy in 367 B. C. the evolution of his mind along the lines existent there springs clearly enough into view for the reader of either the German or the English volume. He apparently was second to none of the disciples of the master in eloquence. He measured foils even with Isocrates; both authors think and both quote the reference to Aristotle's golden stream of talk by Cicero, evidently impressed by that of the dialogues. Thus far as illustrated in this very generalized synopsis of certain features of the two books and in the thoughts to which these give rise, aside from the biographical facts in which they also coincide fairly well, the two authors are in marked agreement, but while Jaeger keeps his mind steadily on the growth of Aristotelian thought and theory and goes much further in tracing their affiliation with the thought and theory of Plato, Ross does not confine himself to this sort of evolutionary objectivity, but most of his book is taken up with a summary of Aristotelian doctrine, which frequently branches into discussion and criticism. Into this there is no space here to go, if we are to devote more of it to the rather unique analysis of Jaeger from a developmental point of view.

He starts with pointing out that in the histories of great thinkers and in the accounts of the evolution of independent creative characters one can not find such another example as this of where one man of nearly equally gifted originality came so intimately and so long under the influence of another commanding genius and stood so long in the latter's shadow. Aristotle came to Plato when the latter was sixty years old and was to live twenty years longer. At that time he had largely himself emerged from the divine aura of the influence of Socrates. In 367 Socrates had been dead more than thirty years. The "Charmides," the "Lysis," the "Laches," the "Apologia," the "Crito" were far back in the dead past. The "Phaedo" and the "Symposium" were alive in the memories of later scholars, but the epoch of platonic form to which these belongs was also closed when Aristotle was a novice. The "Philebus" had some of the old fire in it, but the "Theaetetus" must have greeted him and introduced to him a new aspect of the search after truth and the origin of knowledge. So far as one may judge from the fragments of the early dialogues of Aristotle they were replicas of platonic thought and the form he gave to the expression of it. The wonderful young Macedonian from the half barbarian land of magic was bewitched by the personality and the marvel of the ever-flowing streams from the mind of the great Athenian. He strove to match the magic of the master's dialectic and the traditions of his earlier dialogues, but they were virtually inimitable. They apparently flowed from the inspiration of Socrates, and when the glow from his memory sank below the horizon Plato himself was unable to reproduce it. Nothing since Plato's day has been so often tried, and since then there has been no imitation but has fallen flat. Some of the dialogues attributed to him may have been by his immediate pupils under his guidance and stimulated by his genius. In form or thought or both even these, but especially later imitations, lag so far behind those known to be genuine that there is comparatively little dispute about them. Aristotle's may have been among the best, but later he gave up, probably in realization of his limitations, that form of exposition altogether, and it is significant perhaps that the early dialogues have perished and his in-

dependent works have lived. None but the master could draw the master's bow, we may well believe.

In the "Eudemus" Aristotle treats of the soul as Plato did in the "Phaedo." Even though the neo-platonists regarded both as alike exposing Plato's original thought an earlier antiquity did not name them in the same breath. The "Eudemus" perished, the "Phaedo" lived and so did Aristotle's treatises, in his own manner, in an entirely different form. His "de Anima" ranks with some modern readers at least among the most attractive of the Aristotelian writings, but much in the "de Anima" formed a part of the "Eudemus," just as the "Eudemus" drew on Plato's "Phaedo."

It is true we can not follow everywhere a trail so clearly blazed as this, but Jaeger opens many a vista glancing down which we see the mighty figure of Plato standing at the start. In parallel columns he contrasts what Isocrates had to say in support of shirt-sighted ideals of education with a fragment of the "Protreptikos" of Aristotle urging the view of Plato, who, in advocating the broader view, opposed Isocrates as he rivalled him in his appeal for pupils. The evidence in this instance is not very impressive, but illustrates the extent to which Jaeger is ever ready to go in proving the reality of the early trend of Aristotelian thought in this sense. It is made much more clear by parallel columns that in the "Metaphysics" he followed the old path Jaeger picks out in the "Protreptikos," however little that had to do with Isocrates' "Warning to Demonikos." What more nearly concerns us, in the "Protreptikos," we are reminded by the emphasis he lays upon the exactitude of scientific knowledge that he leans to that kind of knowledge which Plato differentiates in the "Philebus" and in the "Timaeus," if I remember rightly, but this is not mentioned by Jaeger. It is an ideal rather than a practical knowledge observable by the senses and is thus safe from the fallibility and agnosticism of Protagorean doctrine. It is a part of theoretical as distinguished from empirical truth, which we have attempted and partly succeeded in approximating more closely than was possible for the ancients. The margin of error, however, still runs between them. I might further allude to the influence the astronomical views of Eudoxus had on both Plato and Aristotle. He came to Athens, it is said, in the same year as the latter and, though probably he was still further influenced by Kallippus after he had lost Plato and inaugurated the Lyceum, he based much of his "de Caelo" on the older man's astronomy. In much else which I must here omit, for instance, the influence of the Sicilian school of thought which so entangled Plato in more ways than one, we get the origin and growth of Aristotle's doctrines as noted by Jaeger. I must confine myself for lack of space chiefly to that bound up with the platonic origins.

When Aristotle had left the Academy after Plato's death it is believed he erected an altar to his memory somewhere in the plain of Attica. Many modern authors credit the belief advanced by some of the ancients in this, though the evidence seems to rest on a rather uncertain basis, but it is at least to be noted that some of the ancients, who lived not so long after him as some of these modern critics, thought it credible and therefore other stories not worthy of belief which told of Aristotle's estrangement from Plato before the latter's death. Naturally Jaeger finds this in line with the deductions he makes from the fragments of the dialogues and from various parts of the surviving texts of his later work. Dissensions sprang up in the Academy on Plato's death, and it is quite probable it was for the interest of some, perhaps individuals of both factions, to tell stories of Aristotle's disputes with Plato, vivacious discussions naturally arising on various subjects and fire being struck often no doubt from steel such as the minds of these two were made of. But aside from the legendary altar and its inscription "in the Cecropian Plain" Jaeger finds evidence enough to convince us of the force of his views. Indeed, any one reading Aristotle, as Ross specifically points out, will find numerous passages where Aristotle calls himself a platonist, evidently written long after Plato's death, but we may remark that these fragments of dialogues and these texts have seldom if ever hitherto received such a combing over as Jaeger gives them in support of his contentions, and what is far more noteworthy in a German paleographer he makes his story one of vital interest as well as a mine of information.

That Aristotle entirely rejected Plato's theory of ideas, that his politics is far more practical than Plato's "Republic," that his ethics are not precisely those of Socrates is sufficiently known to students, but future students will have no excuse for not knowing how much Aristotle owed Plato. His idea of the soul was practically Plato's carried into the details made possible by the turn he gave to it in his entelecheia and his teleology. The Unmoved Mover remained the Supreme God of Plato, with the difficulties of the conception more systematically discussed. He never freed himself from the oriental demons of the air which Thales received from Babylon. Socrates was frequently listening to one of them, idealized and an allegory for the "still small voice" of future Christians. It was the "light within" of George Fox, and Aristotle's entelechy is but the business end of such mysticisms applied to physiological ends.

Jaeger, still more for us than Ross, has made a loving and lovable personality of Aristotle. He has made him live and breathe for us. He mourns after

his friend, the Cyprian Eudemus, and dedicates a dialogue to him. He writes a moving hymn to Hermias, the uncle of his wife and his own benefactor. He erects an altar to Plato, his master. In his will he directs his bones shall lie with those of his wife Pythias, long since dead, and in accord with her own dying wish that wherever her husband should be buried, her own bones should be dug up and put in the same grave as his. He provides affectionately for his children and slaves. From the dull dialectician of our thoughts he becomes transformed into a personality of great attractiveness and stands side by side with Socrates and Plato as one of the moving figures of antiquity.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

FACTORS THAT INFLUENCE LIFE AND GERMINATION OF COTTON SEED

IN one of our previous papers, we brought out the fact[1] that the temperature which cotton seed can endure, without affecting the vitality of the seed, depends upon several factors: First, the amount of moisture present in the seed; second, whether heated in dry or moist atmosphere; third, and perhaps the most important, whether there is oxygen present during the process of heating. We found that by thoroughly drying and heating cotton seed in a vacuum to prevent oxidation of the fats and proteins in the seed, they will endure a temperature of boiling water for hours without affecting their vitality.

M. J. Hondas and M. A. Guillaumin[2] found that the seeds of the *Gerbera jamesoni* quickly lose their germinative power when exposed to air, because of the alteration occasioned in their fixed or essential oils or in their other elements. In fact, it is impossible to obtain a single germination after a lapse of a single week. As the seed, deprived of albumen, contains alluron, he assumed that its alteration is due at least in part to the oxidizing action of the atmospheric oxygen.

M. A. Guillaumin, using the method employed by the author of storing seed in a vacuum, found he was able to preserve such seed for a long period of time. Since the heating of cotton seeds in a vacuum increased germination and lowered the activity of fungus diseases, we decided to study the effect of heating cotton seed in the presence of chemically inert gases, such as hydrogen, nitrogen and carbon dioxide.

Hydrogen was the first gas to be investigated. After the seeds had been dried at a low temperature, the tubes were filled with hydrogen at 100° C and at atmospheric pressure. The seeds were then subjected to a temperature of 100° C for twenty-six hours. Only in one series of experiments carried out did any of the seeds germinate and then the plants were not as vigorous as untreated seeds, planted on the same date and growing under same conditions.

Upon obtaining such low percentage of germination, oils of the hydrogen treated seeds were extracted with ether by the soxhlet apparatus and iodine numbers determined by the Hubl method. The iodine numbers found ranged from 82 to 99, while the iodine numbers of untreated seeds varied from 104 to 115, which shows that the unsaturated oils that were formerly present in the seed had become partially saturated. From these results we concluded that the oils had been changed by the hydrogen to such a state that prohibited their being hydrolyzed by the enzymes, in order to supply the embryo with necessary food for development. From our experiments there appeared to be no decrease in the activity of the enzymes, incident to heating the seed.

In order to obtain further information in regard to the nature of the absorption of the hydrogen by the oils in the cotton seeds, the tube containing the cotton seed was connected with a very sensitive manometer (see Fig. 1).

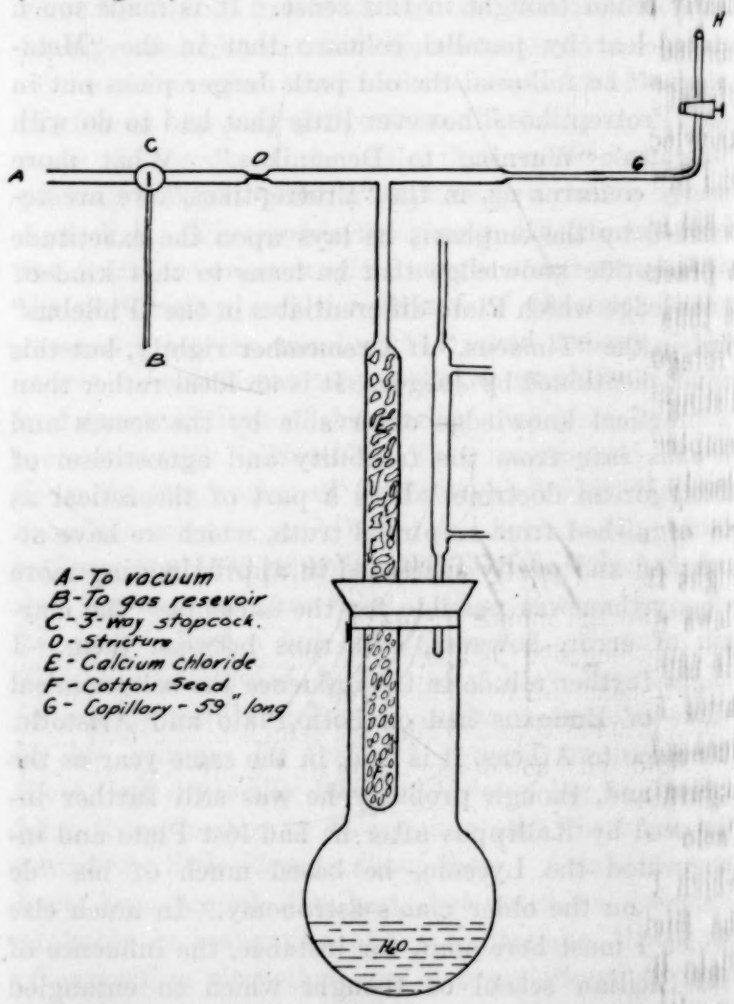

FIG. 1

[1] SCIENCE, Vol. LXII, No. 1487, p. 741.
[2] Bibliothèque Universelle Lausanne, Aug., 1923.

The seed and calcium chloride were placed in the tube as usual and allowed to dry thoroughly. The tube containing the seed was then connected to the manometer. The entire apparatus was evacuated to .001 mm pressure and hydrogen allowed to flow in from a reservoir at atmospheric pressure. In the meantime the water in the flask was heated to boiling. The stricture marked "D" was sealed, thereby confining the gas in the apparatus. The stopcock on the capillary tube was opened and a mercury pellet above it allowed to fall into capillary tube "G."

At the end of thirty hours of continuous heating the mercury pellet advanced the entire length of the tube, indicating the absorption of hydrogen by the oils. The room temperature was held constant within two degrees, as a change of four or five degrees affected the position of the pellet.

Nitrogen was likewise studied in the same way as hydrogen and with one exception a germination of less than 50 per cent. was obtained. The seed which germinated were not as vigorous as untreated seeds planted under the same conditions. After extracting the fats in the treated seed, the iodine numbers were found to correspond closely to those of the original seeds, varying from 105 to 109.

A manometer of the same type as that used with hydrogen was used with nitrogen. Following the first three or four hours of heating the mercury pellet was blown entirely out of the opening marked "H." It was evident that there was a decomposition of the proteins or other vital constituents resulting in a lower percentage of germination. The enzyme action appeared to be normal.

Carbon dioxide was tried upon cotton seed, under the same conditions as previously stated. A decomposition was noticed when the manometer was used, but it was much slower than with nitrogen. At the end of thirteen hours of heating in an atmosphere of carbon dioxide no germination was obtained.

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COLLECTING AMPHIOXUS

DURING the month of March, 1926, I made a collection of some five thousand Amphioxus along the west or gulf coast of Florida. The specimens taken were found in situations varying between a mixture of mud and sand with some vegetation and a mixture of shell and sand. In all cases, sand was the predominant feature of the ocean bottom in which the animals burrowed.

Search for specimens was usually made at low tide. Collecting at other times was mechanically difficult. At low water the bars are more or less exposed and Amphioxus was found in many such bars. The specimens were not scattered but were usually found concentrated along the landward edge of the bar. As the waves roll in over the sandy sea bottom, the bars are built for the most part with a long slope to seaward. On the landward side they frequently show an abrupt drop of a foot or two. The incline of this drop may be as steep as 45 degrees. At the water's edge, along this short but abrupt incline, the Amphioxus were found congregated, at low tide.

When the Amphioxus are abundant their presence is indicated at low tide, by the presence of small holes in the sand. These holes are made by the burrowing animals and are usually at right angles, or nearly so, to the horizontal plane of the water. The animals lie in the burrows near the subterranean water line but whether with the head up or down is not easy to say. Sometimes when the shovel is pushed into the sand an individual Amphioxus will shoot its full length or more out of the sand as though pricked from behind. It seems fairly certain that these specimens come out of their holes head first.

Collecting was carried on as follows. A sieve made of reinforced copper wire tacked on to a square frame was used to sift the Amphioxus from the sand. Three to six or eight Amphioxus was the usual catch for one shovel full of sand. Along with the Amphioxus, there was usually a considerable amount of broken shell. Other animals, such as sand stars, Annelid worms, an occasional Lingula, many empty Dentalium shells with perhaps a few living Dentalium were also present. Now and then a Balanoglossus was noted; on one bar, sand dollars, varying in size from an eighth of an inch up, were found among the broken shell.

The material containing the Amphioxus was dumped on to a square of black oilcloth where the animals flopped about like miniature eels or burrowed beneath the shell and other débris. If by chance they found themselves on the sand of the bar, they disappeared like a flash, head first, into the sand, providing the bar had but recently emerged from the water. If the bar had settled, the animals were frequently unable to bore into it and in dry sand they were helpless. The movements used in boring into the wet sand are nothing more than the lateral oscillations of the body used in swimming. In short, if the sand contains sufficient water, the animals swim down into it.

The depth to which Amphioxus burrow at low tide was not fully determined; in general they seem to keep near the subterranean water level. On bars that yielded an abundance of specimens at ordinary low tide few specimens were to be found at spring tides, at which time these bars are left high and dry. At such low tides, however, plenty of specimens were

secured farther out, that is, near the water's edge. It is hardly possible that the specimens on the bars followed the retreating water since this would, in some instances, have required a migration of several hundred yards. It is more probable that they burrowed deeper and thus kept near to or in the subterranean water.

The collections made in March showed at least two and possibly three generations of Amphioxus to be present in the sand. The oldest specimens were sexually mature, the large females being heavy with eggs. Besides the mature males and females two groups of smaller sized individuals were found. The smallest specimens were less than an inch in length. It would seem, then, that it requires two and possibly three years for this species of Amphioxus to mature.

No observations were made to confirm the statement made by some that the animals leave their burrows and swim freely at night. Collections were made both at daylight and at dark, but no night collecting was attempted. It seems open to doubt, however, that animals which swim as weakly as do Amphioxus could trust themselves to the ebb and flow of the waves on exposed shores and still be able to congregate within the small area in which they are found on the bars between tides.

The species of Amphioxus collected has not been definitely determined. The specimens are now being identified. In general appearance they are much like the common lancelot *Branchiostoma lanceolatum*.

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SPECIAL ARTICLES

CHONDRIOSOMES AND GOLGI APPARATUS IN PLANT CELLS

IN a recent contribution to these columns I outlined the more important results of some studies on the cytoplasmic structures of plant cells as exhibited in the meristem of growing root-tips. The outcome of these studies, like that of similar investigations by plant cytologists, was quite inconclusive as regards the point of most outstanding importance just at present, *viz.*, what cytoplasmic elements in plant and animal cells are homologous. Until we can get at the functional equivalence of the various formed bodies in plant and animal cytoplasm, the enigma of morphological homology would appear to be insoluble. At the present time so little is known of the physiology of chondriosomes and Golgi apparatus that comparisons between plant and animal are in general impossible. But it has occurred to me that the problem of functional equivalence might be approached from a different angle. Thus, we now know with great certainty and elaborate detail the behavior of chondriosomes and Golgi apparatus during the differentiation of the animal sperm. So regular and constant are the essential features of this process that their equivalence can be easily traced throughout the whole range of animal forms. If plants produced sperms comparable to those of animals, it would be at least conceivable that the processes of their differentiation might be capable of direct comparison. Thence conclusions could be drawn with a very high degree of certainty as to the homologies existing between cytoplasmic structures in plant and animal cells.

It so happens that the bryophytes possess sperms remarkably similar, superficially at least, to those of some Platyhelminthes, though unfortunately the structure of the latter has not as yet been very satisfactorily described. This similarity suggests, nevertheless, the possibility that the bryophyte sperm may likewise exhibit the usual characteristics of animal sperm formation. I am now engaged in the task of examining into this possibility, with results which, while still incomplete, seem to give a decisive answer to the long-standing riddles of cytoplasmic homologies. These results are here briefly outlined pending the preparation of a detailed paper.

I have examined the antheridia of Polytrichum juniperinum and P. piliferum, employing the usual osmic acid impregnation methods for the Golgi apparatus, and Fe-hematoxylin methods as often used for study of sperm formation in animals. The early androcytes, which are morphologically equivalent to the animal spermatid, present an appearance so nearly identical to that of an insect spermatid that it is doubtful whether even an expert in animal spermatogenesis could detect any important differences. These early androcytes of Polytrichum contain a spherical nucleus, in close juxtaposition to which is a spherical cytoplasmic structure and scattered bodies which are ring-like in plane view, rods in profile. These cytoplasmic structures exactly correspond to the chondriosome body or nebenkern, and the scattered Golgi bodies, respectively, of practically all insect spermatids. In the differentiation of the moss sperm, the nebenkern presents (though indistinctly on account of its small size) appearances of the differentiation into chromophilic and chromophobic materials so characteristic of insect spermatids. The nebenkern eventually elongates and is applied, together with the blepharoplast filament, along one side of the sperm nucleus, thus vaguely recalling the situation in an animal sperm like that of Lepisma, etc. The scattered bodies gradually merge together to form a mass (first called by M. Wilson the limosphere), which in

its every appearance is strikingly like the acroblast of insect spermatids. The differentiation of an apical body or acrosome in association with this mass has been established, the details being similar to the processes which I have heretofore described in many insects. The manner of deposition of the apical body does not, however, agree with the account previously given by Allen (Ann. of Botany, vol. 31, 1917). The acrosome having been separated from the so-called limosphere, the latter is eventually cast out of the sperm in the rejected protoplasmic ball, as in the case of the acroblast (Golgi remnant) in animal sperms.

This history leaves, to my mind, no reasonable doubt that the nebenkern body in mosses represents the homologue of the similar body in insects, and hence is composed of material directly homologous to the chondriosome content of animal cells. Similarly, that the limosphere represents the Golgi complex so familar in the insect sperm. Tracing these materials back into the androgonial generations, I find that the Golgi material reappears as scattered, disc-like bodies with a heavily impregnated peripheral rim, while the chondriosome material is represented by the kinetosomes, in earlier generations the polar plates, of Allen's descriptions. Direct proof of this identification is lacking, due to the absence thus far of the essential division stage in my preparations, but the morphological details and other features which can not here be entered into leave practically no doubt of the genetic relations of the two materials involved.

Passing now into the cells which form the epidermis of each antheridium, and thence into the cells of the perigonial leaves, we find always two kinds of cytoplasmic elements demonstrated simultaneously with those of the spermogenous cells. One of these is the plastids, the other, bodies scattered through the cytoplasm and morphologically identical with the scattered "Golgi bodies" of the androgonia and early androcytes. In other words, in somatic tissues the nebenkern material of the androcytes seems to be represented by the plastidome, and the Golgi bodies by the spherome of the Dangeards' nomenclature. That considerable gaps are left in the connecting links of proof, I frankly concede, but the general picture is so unequivocal that I believe extended researches will eventually provide critical proof of the homologies here made out. It is of the greatest interest that the spherome in spermogenous tissue and in leaf tissue of mosses should be so like that in plant root-tips, as reported in my previous note. Further, the comparison of the chondriosome material to that of the chloroplastids is borne out by the known origin of plastids from bodies which react in a manner characteristic of animal chondriosomes. a fact indeed which early led to their identification as such. These considerations, together with others which can not be argued in the short space of this article, leave me no alternative but to conclude: (1) that the plastidome of plant cells is the homologue of the animal chondriome and (2) that the spherosome ensemble (spherome) is the homologue of the animal Golgi apparatus. This conclusion seems to increase the probability of the suggestion put forward in my previous note to the effect that the chondriosomes in general may represent the physical basis of carbohydrate metabolism. The homologizing of the apparently inactive spherosomes with the Golgi apparatus in animal cells perhaps introduces some theoretical difficulties which can not at present be profitably considered.

The conclusion here reached leaves the problem of the plant vacuolar system, judged by some workers to be the homologue of the Golgi material, in a state even more unsettled than before. It is possible that further research will bring out some relation between the vacuome and the Golgi apparatus (spherome), but at present this does not seem very probable. The recent findings of Lloyd and Scarth (SCIENCE, Vol. 63, 1926) relative to the origin of vacuoles from preexistent lipoid bodies, certainly agrees in a general way with my own studies in the root-tip cells of Vicia faba. But I have been unable to demonstrate any vacuome in the spermogenous tissue of mosses, and if it be represented there, it seems scarcely likely to be related to anything known in animal sperm cells. It is possible that an answer may be found in the recent work of Nassonov and of Lowther on the Protozoa. Nassonov finds that the contractile vacuole is always associated with a lipoidal substance, which he homologizes with the Golgi apparatus. But Lowther finds scattered bodies probably equivalent to the Golgi apparatus and quite without relation to the lipoidal wall of the contractile vacuole. These observations suggest that vacuoles are everywhere associated with lipoidal materials in the form, generally speaking, of an enclosing membrane, as De Vries long ago postulated in his tonoplast theory. Further, that in this respect the plant and protozoan vacuoles may be, to an unknown extent, equivalent, but in general without known representatives in the cells of higher animals. Thus it would be possible through Lowther's results to bring the Golgi material in Protozoa into line with the spherome of plant cells and the well-known Golgi apparatus of all Metazoa, while consigning the lipoidal basis of vacuoles possibly to a new, hitherto specifically unrecognized category of cellular consitituents. It will be quite apparent that our whole knowledge of normal vacuoles is as yet very unsatisfactory and that in attempting to find a solution of their morphological meaning it will be a